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Integrated Polycrystalline Silicon Resistor with Carbon or Germanium

The invention relates to an integrated high ohmic polycrystalline silicon resistor and to a method of its fabrication.

In microelectronics integrated resistors are being used in analog as well as in digital circuits or control circuits. These resistors are to posses the lowest possible tolerances and a high stability. Resistors based upon polycrystalline materials are a particularly cost-efficient variant, but for many applications high ohmic resistors in particular do not attain sufficient values of stability and tolerance.

In integrated circuits, semiconductor resistors are used because of their compatibility with conventional technological methods of fabrication and because of relatively simple possibilities of variation as, for instance, by doping. Amorphous as well as polycrystalline semiconductor layers, silicon in particular, are used as the basic material. Resistance properties such as, for instance, resistance value, resistance tolerances and temperature stability are essentially determined by the geometric dimensions of the resistance layer, by the basic material used, by the doping elements, the doping method applied, by the doping concentration and by the ensuing processes, above all by the temperature/time stresses arising in connection therewith.

Because of their grain structure, problems of stability arise in high ohmic polysilicon layers. These are caused in particular by the out-diffusion

of the dopants from the monocrystalline areas, the segregation of the dopants at the grain boundaries, the attachment of charge carriers in deep traps of the corn boundaries as well as by the formation of potential barriers at the corn boundaries associated therewith. The increase in resistance tolerance resulting therefrom, particularly by the temperature/time stress in ensuing process steps, and in the temperature coefficient leads to limitations in the application of high-ohmic polycrystalline resistors.

It is the task of the invention to propose an integrated high-ohmic polycrystalline silicon resistor and a method of its fabrication, in which the sensitivity to tolerances during the fabrication process and, hence, the resistance tolerance value are improved and the temperature coefficient is reduced relative to conventional resistors of this kind. Furthermore, it is a task of the invention to raise the stability of such resistors.

This task is accomplished, in accordance with the invention, by reducing the diffusion or the diffusion coefficient of the doping elements within the monocrystalline grains by the incorporation of carbon and/or by the use of polycrystalline SiGe with or without the addition of carbon.

In this manner it is possible to fabricate high-ohmic polysilicon resistors, having, in particular, resistance layer thicknesses $R_s \geq 10^3\ \Omega/\Box$ with improved values of tolerance and stability.

A precipitation of $Si_{l-y}C_y$ or SiGeC is used, instead of the hitherto conventional precipitation of pure and usually amorphous or polycrystalline Si layers followed by implantation and annealing or *in situ* doping with doping elements such as, for instance, boron, phosphorus, arsenic or antimony.

In this connection use is being made of the effect that adding carbon leads to a reduction of the diffusion coefficient of the doping elements, in

particular of boron, and thus to a reduction or prevention of the segregation effects at the grain boundaries or of the out-diffusion of the doping elements from the monocrystalline areas. This results in stabilization of the potential barrier and thus leads to a reduction in the temperature dependency of the resistor.

The use of SiGe as a basic material also leads to reduced temperature dependency.

The addition of carbon and/or germanium to the silicon may be carried out, for instance, *in situ* or by implantation followed by annealing.

The above-mentioned effects are improved by combining the two additives as a SiGe layer.

It is thus possible by the described method to fabricate high-ohmic polycrystalline silicon resistors with reduced temperature coefficients, increased stability and improved tolerance values.

Aside from the claims the characteristics of the invention are also apparent from the specification and drawings, the individual characteristics by themselves or in any combination constituting protectible embodiments for which protection is being sought here.

An embodiment of the invention is presented in the drawing and will be described in greater detail hereinafter.

Fig. 1 schematically depicts the structure of an integrated polycrystalline resistor. The resistor in accordance with the invention consists of a substrate 1, a dielectric substance 2, a doped polycrystalline layer 3 and metallic contacts 4. The polycrystalline layer 3 may consist of SiGeC, but

$Si_{1-y}C_y$ or SiGe also lie within the ambit of the invention. The geometric dimensions and the doping of the polycrystalline layer 3 depend upon the resistance value to be achieved.

For purposes of fabrication, a dielectric substance 2 is precipitated on a substrate 1. This is followed by precipitation and structuring of the polycrystalline or still amorphous layer 3. In addition to boron doping, carbon and/or germanium is added to the silicon *in situ* or by implantation and subsequent annealing. The concentration of boron, carbon and germanium also depend upon the resistance value to be achieved. This is followed by a further precipitation of the dielectric substance 2 and by the fabrication of the metallic contacts 4.

In connection with the present invention, an integrated high-ohmic polycrystalline silicon resistor and a method of its fabrication have been described on the basis of a concrete embodiment. It is, however, to be noted that the present invention is not limited to details of the embodiment described, since alterations and mutations are being claimed within the scope of the claims.